Ammonia Losses From a Commercial Cattle Feedlot: Towards a Realistic NH_3 Emissions Inventory for the Great Plains

Principal Investigators:

J.M. Ham, G.M. Pierzynski, R.G. Maghirang,

W.L. Hargrove, J.M. DeRouchey

Graduate Students

K. Baum, G. Vaillant

Advisors

J. Brethour , J. Meisinger

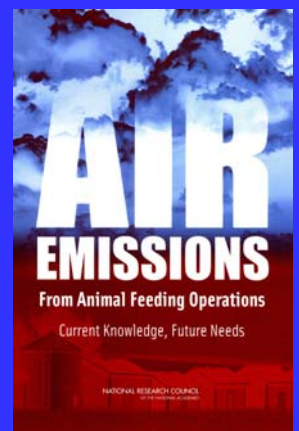
COLLEGE OF AGRICULTURE

KANSAS STATE UNIVERSITY

TABLE ES-1 Committee's Scientific Evaluation of the Potential Importance[a] of AFO Emissions at Different Spatial Scales

Emissions	Global, National, and Regional	Local—Property Line or Nearest Dwelling	Primary Effects of Concern
NH_3	Major[a]	Minor	Atmospheric deposition, haze
N_2O	Significant	Insignificant	Global climate change
NO_x	Significant	Minor	Haze, atmospheric deposition, smog
CH_4	Significant	Insignificant	Global climate change
VOCs[b]	Insignificant	Minor	Quality of human life
H_2S	Insignificant	Significant	Quality of human life
PM10[c]	Insignificant	Significant	Haze
PM2.5[c]	Insignificant	Significant	Health, haze
Odor	Insignificant	Major	Quality of human life

NRC, 2003



Objectives

- Measure the fluxes of NH_3 and NH_4 aerosol from a large block of pens (e.g., 10,000 head) at a commercial cattle feedlot.

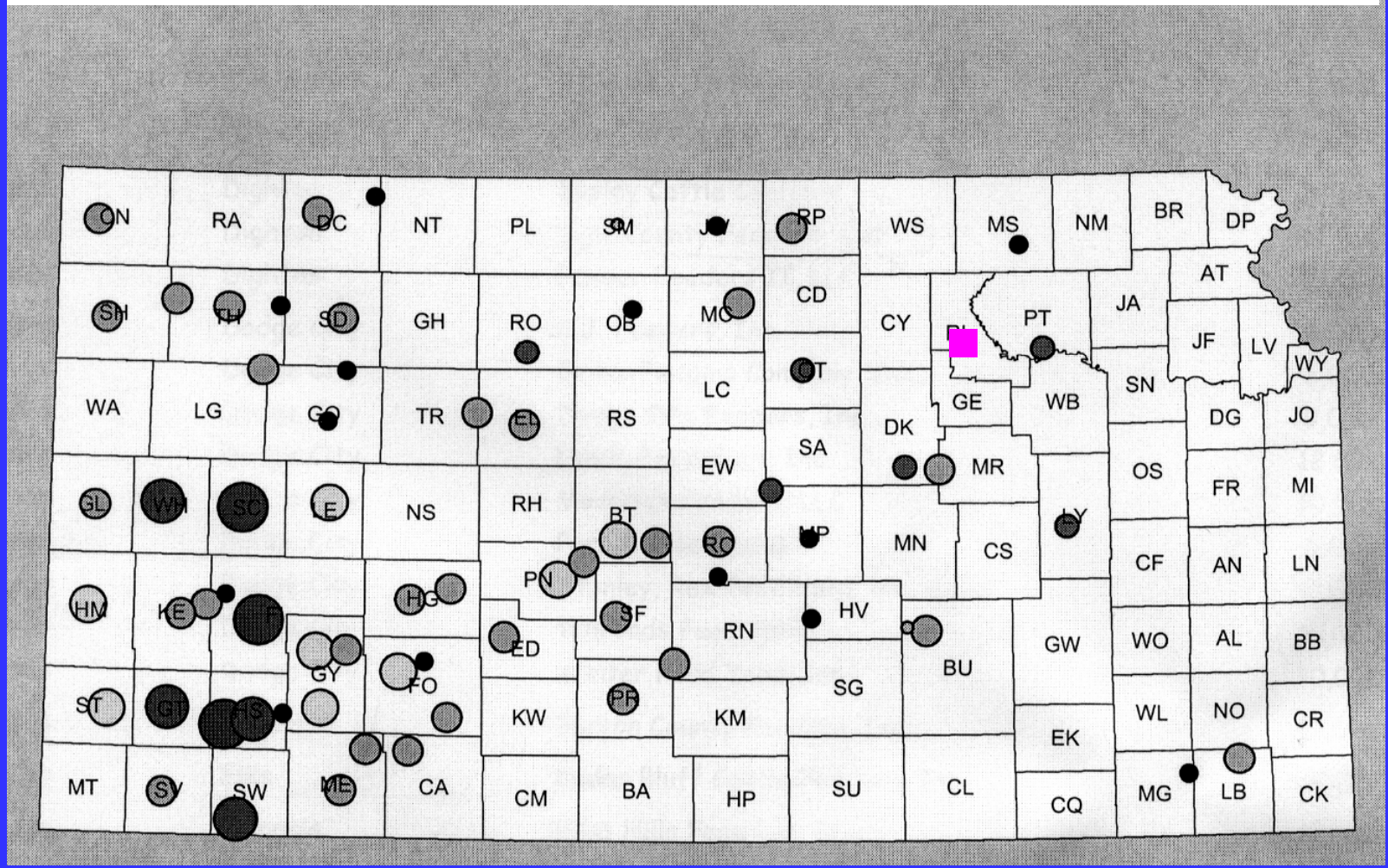
- Compare the atmospheric NH_3 flux measurements to other parameters in the feedlot nitrogen balance

Objectives

- Analyze the relationship between feed-nitrogen and NH_x emissions in response to weather conditions, boundary-layer physics, soil moisture, and soil chemical conditions at the pen surface.

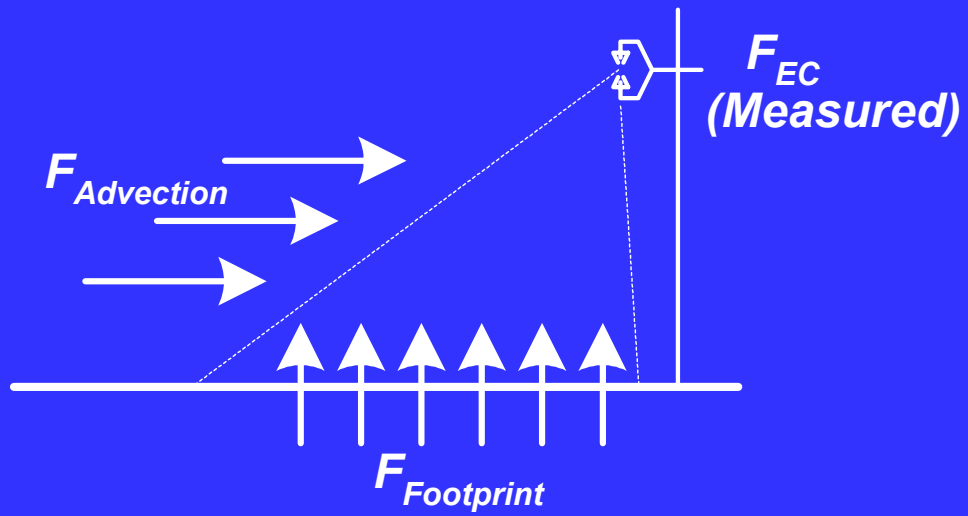
- Develop and test variations of the relaxed eddy accumulation (REA) technique for measuring NH_x flux. Study the impact of spatial variation.

Kansas Beef Cattle Capacity (au)



Preliminary Objectives

1. Determine the significance of horizontal advection at a cattle feedlot (spatial variation in flux).
2. Determine aerodynamic roughness



$$F_{Ft} = \int_0^{z_r} \frac{\partial \bar{c}}{\partial t} dz + \left(\overline{w'c'}\right)_{z_r} + \int_0^{z_r} \left\{ \bar{u} \frac{\partial \bar{c}}{\partial x} + \bar{w} \frac{\partial \bar{c}}{\partial z} \right\} dz$$

$$F_{Ft} = F_{Stg} + F_{EC} + F_{Adv}$$

Methods and Materials

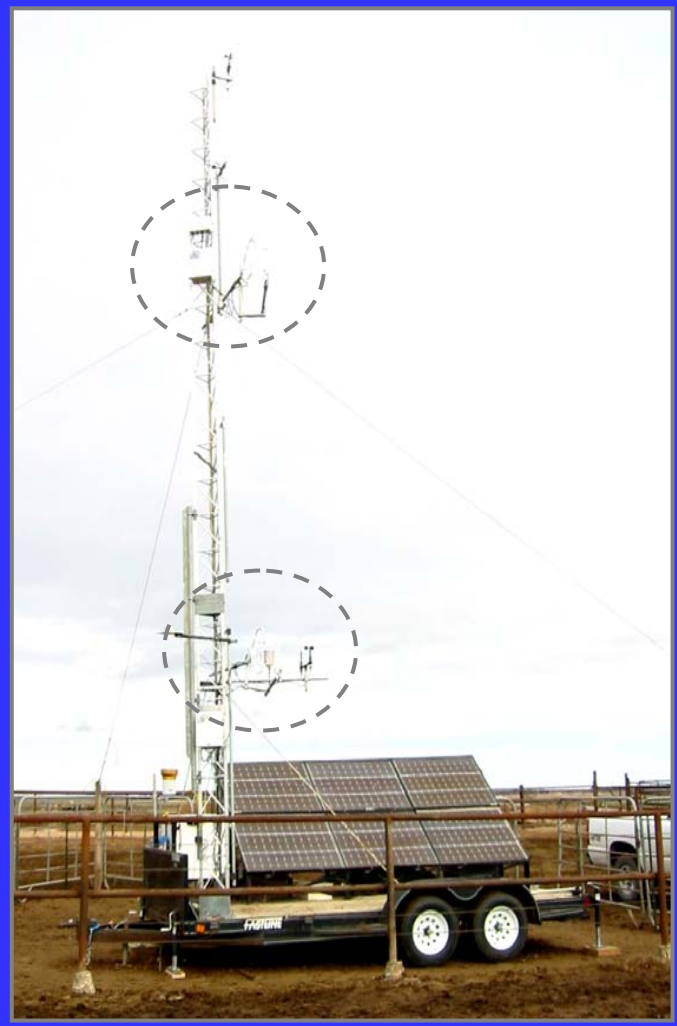
Eddy Covariance (EC) components:

- 3-D Sonic Anemometer: measures 3-dimensional wind speed.
- Open-path Infrared Gas Analyzer (IRGA): measures concentrations of water vapor and CO_2.

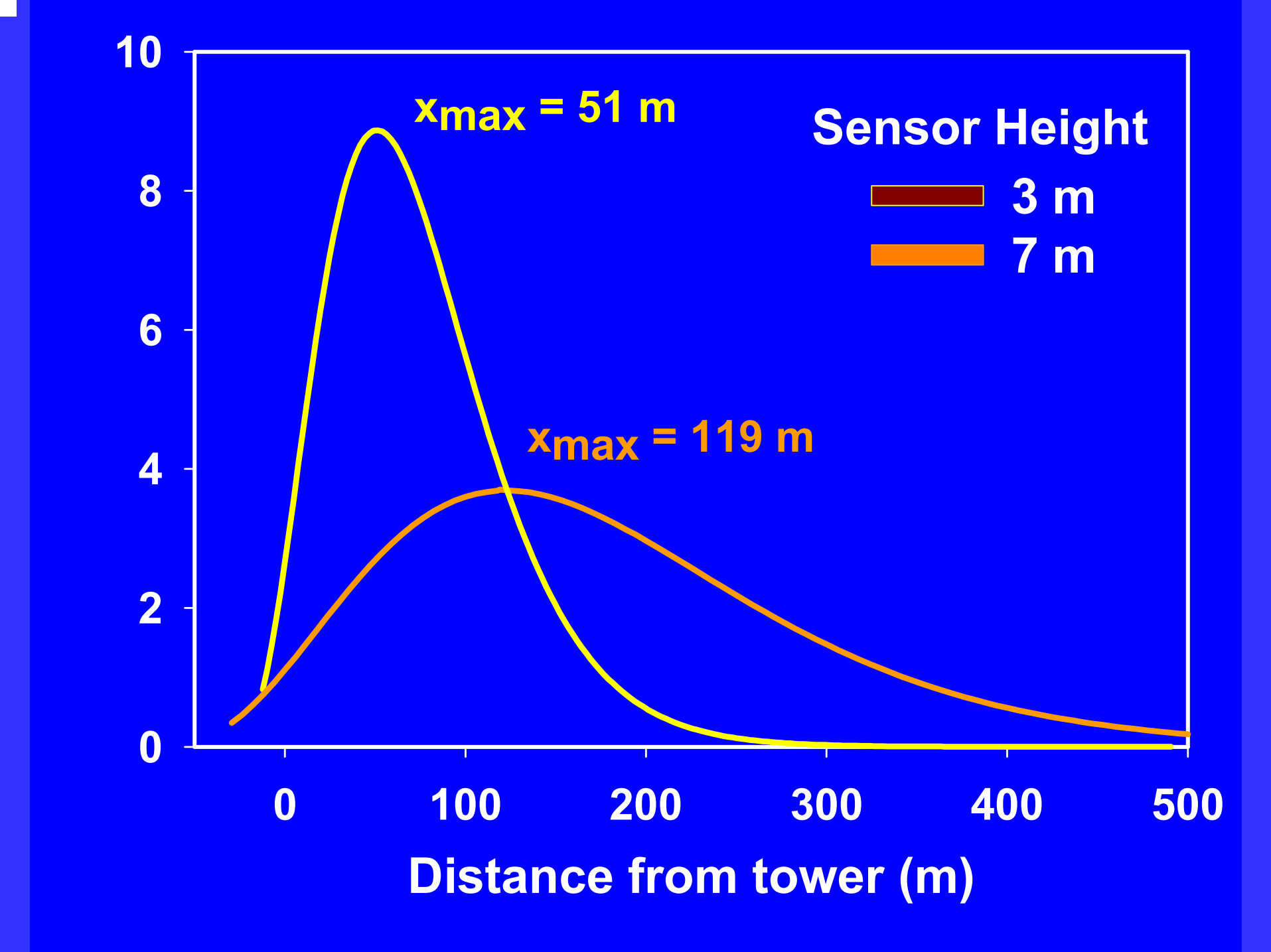
Both taking measurements at 10 Hz.

Methods and Materials

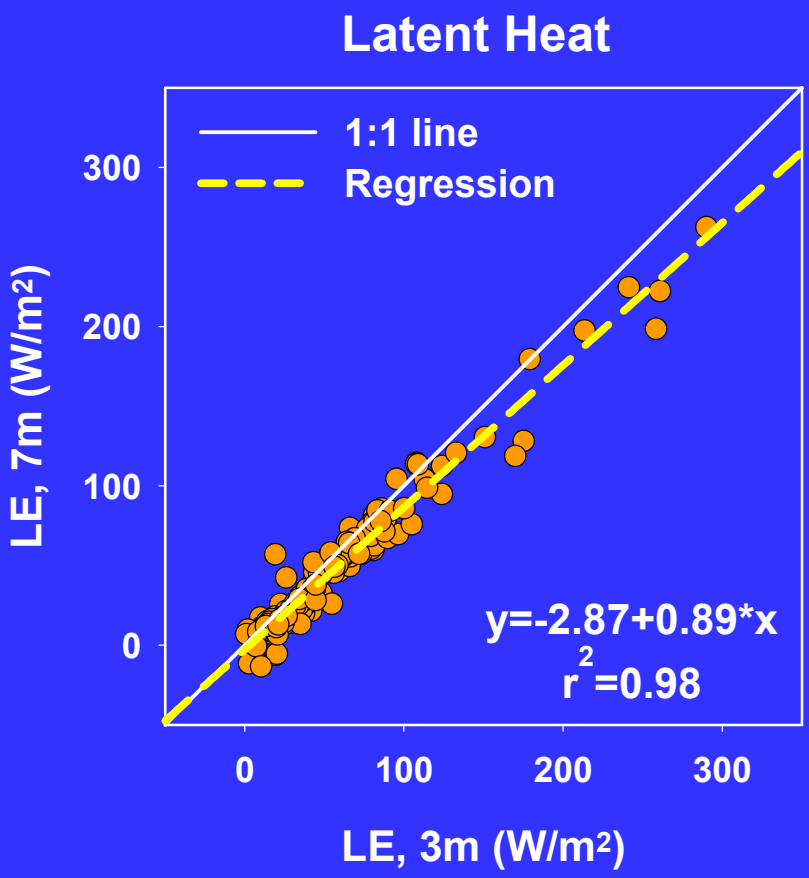
- Two Eddy Covariance (EC) systems at 3 m and 7 m above the pen surface.
- Fluxes measured at the two heights should be the same, if advection or differences in the footprint are not present.
- Sonic anemometer data is used to calculate z_0 at each height.

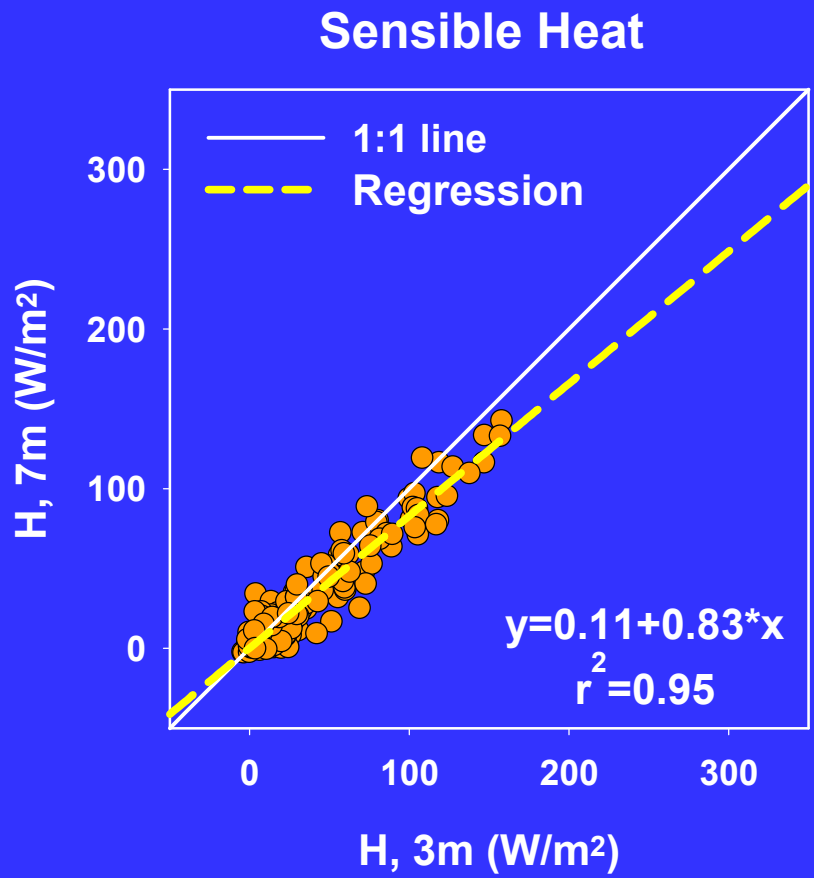



FASTLINE

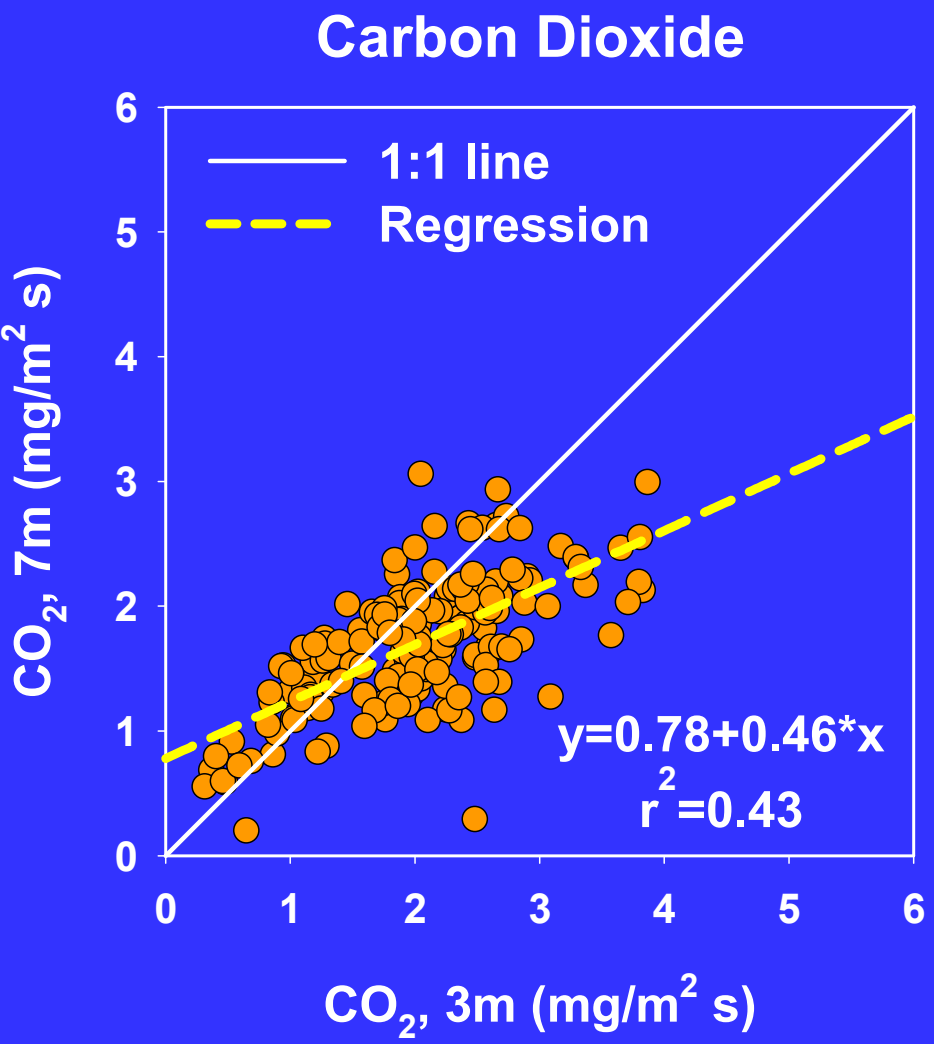

10
8
6
4
2
0
x_{max} = 51 m
x_{max} = 119 m
Sensor Height
3 m
7 m
0
100
200
300
400
500
Distance from tower (m)

Results: Advection





Results: Advection



Results: Roughness

Median z_0:

3 m = 5.0 cm

7 m = 3.3 cm

Surface Type	z_0 (cm)
Concrete*	0.02-0.05
Fallow ground*	0.1-0.4
Short grass*	0.8-3.0
Cattle feedlot	**2.0-6.0**
Mature grain crops*	12-18
Dense, low buildings*	40-70
Mature pine forest*	80-160

Measuring Emission Rates by Relaxed Eddy Accumulation (Conditional Sampling)

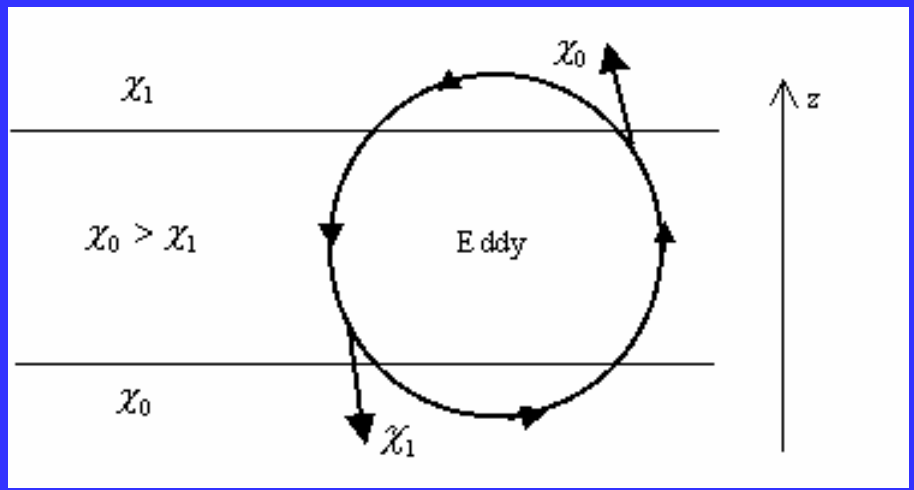
$$J\chi = 0.58\sigma_w \rho(\chi_{up} - \chi_{dn})$$

J = Flux density

σ = std. dev. vert. wind

ρ = air density

χ = mixing ratio



Short-Term Goals, Summer 2005

- Testing and deployment of REA methods for NH_x flux measurement
- Soil chemical analysis of pen surface and subsurface
- Evaluation of feeding records & start nitrogen balance measurements
- Particulate analysis
- Finish analysis of feedlot boundary layer

Research Needs / Collaboration

- Continuous / real-time techniques for measuring NH_3 and NH_4 with adequate resolution for micrometeorological flux measurement.
- Modeling the chemistry and hydrology of the pen surface.

Acknowledgements

- NRI Integrated Air Quality program
- Feedlot Cooperators
- Kansas Livestock Association
- Kansas State Research and Extension

COLLEGE OF AGRICULTURE
KANSAS STATE UNIVERSITY


Questions ?